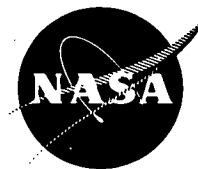


NASA TECH BRIEF

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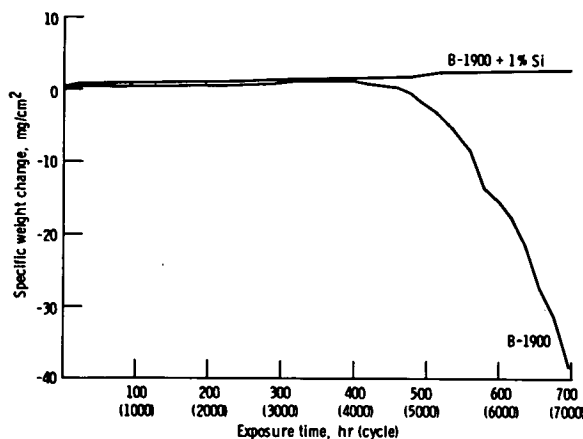
Addition of Silicon Improves Oxidation Resistance of Nickel Based Superalloys

The addition of one weight percent silicon to the nickel-base superalloy B-1900 (nominal composition in weight percent: 0.10 carbon, 8.0 chromium, 10.0 cobalt, 6.0 molybdenum, 1.0 titanium, 6.0 aluminum, 0.015 boron, 0.10 zirconium, 4.0 tantalum, with balance nickel) has been shown to markedly improve its cyclic oxidation resistance.

B-1900 and B-1900 + 1% Si were tested by cyclic heating in air to 1273 K (1832°F) and 1373 K (2012°F) for 7000 and 2000 cycles, respectively. Each cycle consisted of 6 minutes in the furnace and 9 minutes cooling in still air. Thus, total heating times were 700 and 200 hours at, respectively, 1273 K (1832°F) and 1373 K (2012°F).

Specific weight change of B-1900 and B-1900 + 1% Si specimens tested at 1273 K (1832°F) is shown as a function of heating cycles in the figure. At the end of the test, B-1900 was losing weight at an increasing rate due to spalling of the oxide scale while B-1900 + 1% Si was still gaining weight at a low, nearly constant rate. A similar comparison in weight change was observed for the specimens tested at 1373 K (2012°F).

Metallographic examination of the oxidized specimens showed that below the oxide scale the depth of alloy depleted in the strengthening gamma prime phase was much less in B-1900 with silicon added.



The effect of Si on the resistance to cyclic oxidation of B-1900 at 1273 K (1832°F).

In earlier work, it was shown that the addition of silicon greatly improves the cyclic oxidation resistance of trinickel aluminum, Ni_3Al , the basis of the gamma prime phase in nickel-base superalloys. Since the same effect has been observed in B-1900, an alloy which contains about 60 volume percent gamma prime, there is promise that silicon may also provide improved oxidation resistance for other gamma-prime-strengthened nickel-base superalloys.

It must be pointed out, however, that silicon is commonly held to be damaging to the mechanical properties of nickel-base superalloys. It is normally present in these alloys only as a "tramp" element and maximum concentrations of a few tenths percent are allowed by alloy specifications. It is not clear in how many of these alloys silicon has been demonstrated to be detrimental. Regardless of this question, the possible improvement in oxidation resistance due to silicon would appear to be ample justification for studying the effects of controlled silicon additions in the development of new high temperature alloys.

Notes:

1. Further information is available in the following reports:

NASA TM-X-68191 (N73-16564), Improvement in Cyclic Oxidation of the Nickel-Base Superalloy B-1900 by the Addition of One Percent Silicon

NASA TN-D-6838 (N72-26434), The 1200°C Cyclic Oxidation Behavior of Two Nickel-Aluminum Alloys (Ni_3Al and NiAl) with Additions of Chromium, Silicon, and Titanium

Copies may be obtained at cost from:

Aerospace Research Applications Center
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Reference: B74-10007

(continued overleaf)

2. Specific technical questions may be directed to:
Technology Utilization Officer
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Cleveland, Ohio 44135
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Patent Status:

NASA has decided not to apply for a patent.

Source: C.E. Lowell and R.V. Miner, Jr.
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